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EVALUATION OF MILITARY SPECIFICATION AIRCRAFT COATINGS (AVSCOM --ETC(U)
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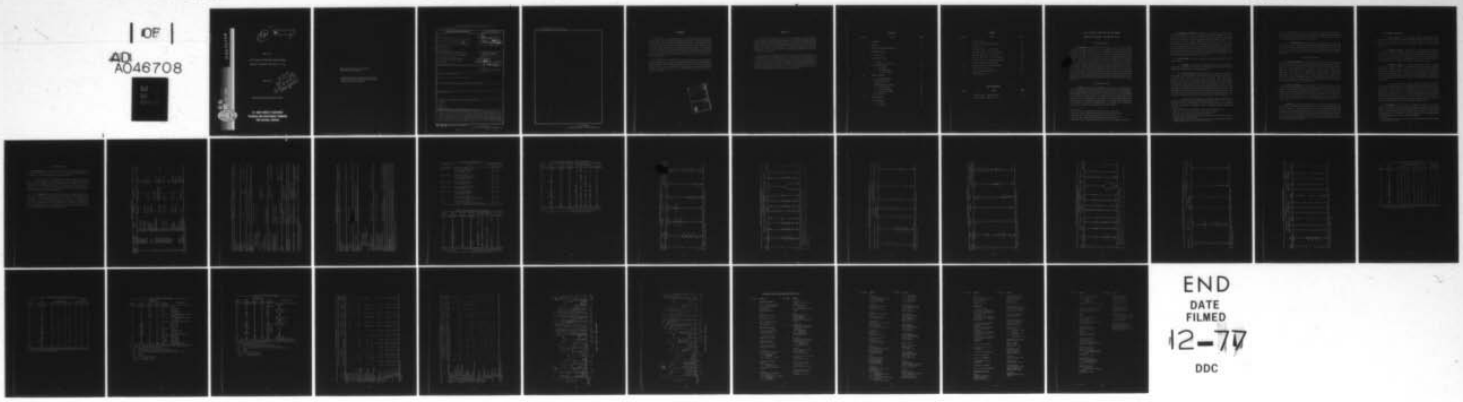

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EVALUATION OF MILITARY SPECIFICATION AIRCRAFT COATINGS (AVSCOM NO. 77-18)

August 1977

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: 2218
2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER: (9)

4. TITLE (and Subtitle): (6) EVALUATION OF MILITARY SPECIFICATION AIRCRAFT COATINGS (AVSCOM Number 77-18)
5. TYPE OF REPORT & PERIOD COVERED: Final rept. June 1972 – December 1976
6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s): (10) Melvin H. Sandler, Fred L. Lafferman
8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS: U.S. Army Mobility Equipment Research and Development Command, ATTN: DRDME-VO, Fort Belvoir, Virginia 22060
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS Code 1498.95.2-P8111(XW2) Proj No. 1728111

11. CONTROLLING OFFICE NAME AND ADDRESS: U.S. Army Aviation Systems Command, DRSAV-EXT, St. Louis, Missouri 63166
12. REPORT DATE: August 1977
13. NUMBER OF PAGES: 37 (12) 31p.

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
15. SECURITY CLASS. (of this report): Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Coatings
Polyurethane
Acrylic
Nitrocellulose
Urethane-Acrylic

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report covers a comparison study on the properties of military specification aircraft finishes. Coatings representing olive drab and white gloss and camouflage (lusterless) specification polyurethane, acrylic, and nitrocellulose-acrylic finishes were investigated. Also included were a one-package, moisture-cure urethane and an experimental urethane-acrylic coating. Based on this study, Specification MIL-C-83286 (USAF) "Coating Urethane, Aliphatic Isocyanate, for Aerospace Application" should be used for Army Aircraft where a gloss finish is required and Specification MIL-L-81352 (AS) "Lacquer Acrylic (for Naval Weapons Systems)," where a lusterless finish is required.

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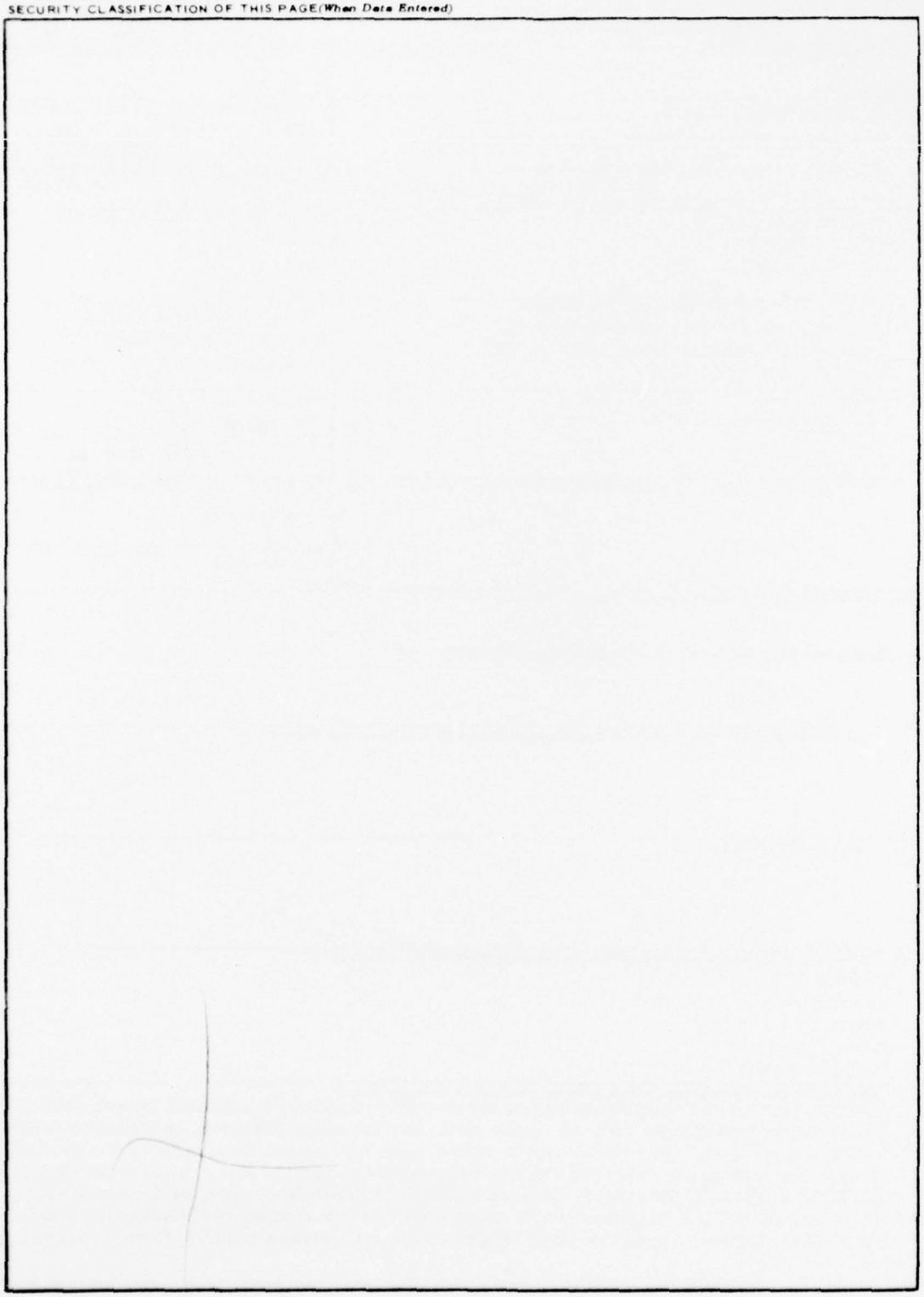

SUMMARY

This report covers a comparison study on the properties of military specification aircraft finishes. Army aircraft are being painted with acrylic and acrylic-nitrocellulose lacquers. In recent years, aliphatic urethanes, claimed to have outstanding gloss and color retention as well as improved flexibility and hydraulic fluid and abrasion resistance, have been introduced for use on high-performance aircraft. A one-package, moisture-cure urethane and an experimental urethane-acrylic coating were also investigated. For this program, comparison of overall coating performance has been stressed rather than properties which reflect product characteristics such as fineness of grind, gloss, and drying time.

Based upon the data obtained in this study and taking into consideration such things as application ease, cost, and operational requirements, Specification MIL-C-83286 (USAF) "Coating Urethane, Aliphatic Isocyanate, for Aerospace Application" should be used for Army Aircraft where a gloss finish is required and Specification MIL-L-81352 (AS) "Lacquer, Acrylic (for Naval Weapons Systems)," where a lusterless finish is required.

PREFACE

This report was prepared for the U.S. Army Aviation Systems Command, St. Louis, Missouri, by the U.S. Army Mobility Equipment Research and Development Command under USAVSCOM MACI Project 8111, "Testing of Commercial Polyurethane Paints." This work was initiated under Project No. 1728111, "Evaluation of Military Specification Aircraft Coatings." The work was administered under the direction of the Director of Research, Development and Engineering, U.S. Army Aviation Systems Command.

This project was accomplished as part of the U.S. Army Aviation Systems Command Manufacturing Technology Program. The primary objective of this program is to develop, on a timely basis, manufacturing processes, techniques, and equipment for use in production of Army material. Comments are solicited on the potential utilization of the information contained herein as applied to present and/or future production programs. Such comments should be sent to: U.S. Army Aviation Systems Command, ATTN: DRSAV-EXT, P.O. Box 209, St. Louis, Missouri 63166.

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I. INTRODUCTION

1. **Background.** Army aircraft have been painted with acrylic-nitrocellulose lacquers in accordance with MIL-L-19537[1] and MIL-L-19538[2] and acrylic lacquer in accordance with MIL-L-81352.[3] In recent years aliphatic urethanes, claimed to have outstanding gloss and color retention as well as improved flexibility and hydraulic fluid and abrasion resistance, have been introduced for use on high-performance aircraft. Coatings of this type are represented by Specifications MIL-C-81773[4] and MIL-C-83286.[5] In June 1972, the Coating and Chemical Laboratory (CCL), Aberdeen Proving Ground (APG), Maryland, was requested by the Aviation Systems Command (AVSCOM) to conduct a study comparing the urethane to the current systems to provide data that could be used for the selection of finishes that would be most cost effective for Army aircraft. When the Chemical and Coating Laboratory was disbanded, the work was continued at the US Army Mobility Equipment Research and Development Command, Fort Belvoir, Virginia. The coatings tested were obtained from commercial sources or the Federal Supply System or were prepared within the laboratory. Test panels were prepared and exposed at APG and at tropic sites in Fort Sherman, Panama Canal Zone.

II. DETAILS OF TEST

2. **Coatings.** Twenty eight coatings (Table 1) representing olive drab and white gloss and lusterless proprietary and specification urethane, acrylic, and nitrocellulose-acrylic aircraft finishes were obtained from commercial sources or the Federal Supply System (GSA), or were prepared by CLL. Each specification-type coating (MIL-L-19537, MIL-L-19538, MIL-L-81352, and MIL-L-81773) was initially screened for compliance to its own requirements. All coatings were then compared to MIL-C-83286 which imposes the most stringent requirements. The nonspecification urethanes were also evaluated in accordance with MIL-C-83286. A synopsis of the performance characteristics required by the specifications is covered in Table 2.

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1 MIL-L-19537, "Lacquer, Acrylic-Nitrocellulose, Gloss (for Aircraft Use)," May 15, 1965.

2 MIL-L-19538, "Lacquer, Acrylic-Nitrocellulose, Camouflage (for Aircraft Use)," May 11, 1970.

3 MIL-L-81352 (AS), "Lacquer; Acrylic (for Naval Weapons Systems)," Feb 10, 1972.

4 MIL-C-81773 (AS), "Coating, Polyurethane, Aliphatic, Weather Resistant," Feb 22, 1971.

5 MIL-C-83286 (USAF), "Coating, Urethane, Aliphatic Isocyanate, for Aerospace Application," Sept 25, 1970.

3. **Preparation of Test Panels.** Test panels for the laboratory tests were 24 gage, 2024 Alclad aluminum in T3 and T0 tempers as required by MIL-C-83286. The exterior-exposure panels were 18 gage, 2024 T3 aluminum. All panels were pretreated with chemical-conversion material conforming to Type II of MIL-C-81706.[6] Primers and topcoats were spray applied according to the applicable specification to the specified, dry-film thickness (DFT) using an automatic spray apparatus. The systems for each coating are listed in Table 3. In addition, a set of panels was prepared with the nitrocellulose-acrylic lacquers using the epoxy primer[7] in lieu of the wash primer[8] / lacquer primer[9] system. Also, an additional set of panels with the proprietary, one-package urethane was prepared for exterior exposure using a primer supplied by the manufacturer in lieu of the specification epoxy primer.

4. **Test Procedures.** Tests were conducted in accordance with MIL-C-83286 except as follows:

a. **Flexibility.** In addition to being subjected to the low-temperature, flexibility test of MIL-C-83286, coatings were also subjected to bend tests at room temperature after 500 hours of accelerated weathering.

b. **Exterior Exposure.** Coatings were exposed at APG at an angle of 45° facing south and at Fort Sherman, Panama Canal Zone, at a tropical, open-field site. These panels were exposed at an angle of 30° facing south. After each exposure period, the panels were examined for chalking in accordance with ASTM Method D659-44, and the panels were then washed with a mild soap solution, rinsed and dried, and appearance measurements were made. The 20° specular gloss of the gloss coatings was measured in addition to the 60° gloss required by MIL-C-83286 because a coating will at times have a high gloss at one angle of viewing but when viewed at other angles will display a haze that detracts from the sharp gloss the coating seems to have. The 20° gloss provides a measure of this haze, and a combination of high readings for both 20° and 60° gloss indicates a film that will provide the most desirable appearance.

Additionally, the coatings were subjected to the knife test in accordance with Method 6304 of Federal Test Method Standard No. 141.[10] In this test, the coating is cut with a knife blade held at an angle of approximately 30° to the panel. The knife test provides a qualitative measure of intercoat adhesion (adhesion of

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[6] MIL-C-81706, "Chemical Conversion Materials for Coating Aluminum and Aluminum Alloys."

[7] MIL-P-23377, "Primer Coating, Epoxy-Polyamide, Chemical and Solvent Resistant."

[8] MIL-C-8514 (ASG), "Coating Compound, Metal Pretreatment, Resin Acid."

[9] MIL-P-7962, "Primer Coating, Cellulose Nitrate Modified Alkyd Type Corrosion Inhibiting, Fast Drying (for Spray Application Over Pretreatment Coating)."

[10] Federal Test Method Standard No. 141, "Paint, Varnish, Lacquer and Related Materials, Methods of Inspection, Sampling and Testing," Sept 1, 1965 (Change Notice 4, May 1, 1974).

topcoat to primer), adhesion of system to metal, film toughness, and film flexibility. In general, very brittle coatings will chip or flake; those with medium flexibility will ribbon slightly and then crumble; and those with good flexibility will form a continuous ribbon with the knife cut showing a beveled edge.

c. **Abrasion Resistance.** Coatings were spray applied to a dry-film thickness between 1.7 and 2.0 mils to aluminum panels, air dried a minimum of 7 days, and tested in accordance with Method 6192 of Federal Test Method Standard 141 using CS 17 abrasive wheels with a 100-gram load per wheel. Wear Index was determined after 325 cycles. The abrasive wheels were resurfaced with S 11 abrasive paper after each 30 cycles.

III. INVESTIGATION

5. **General Requirements.** For this program, comparison of overall coating performance has been stressed rather than properties which reflect product characteristics such as fineness of grind, gloss, and drying time. The screening tests indicated that those coatings supplied under or prepared for MIL-L-19537, MIL-L-19538, MIL-L-81352, and MIL-C-81773 basically met their specification requirements although in several instances the original gloss was slightly lower than specification requirements. Even though none of the coatings, including those supplied under MIL-C-83286, complied with all requirements of that specification, sufficient data was developed to permit a meaningful comparison of the coatings. Where specific details are desired, Tables 4 through 13 should be consulted.

6. **Corrosion Resistance.** The laboratory and exterior-exposure studies indicated that all coating systems will provide generally good corrosion resistance. Except for three gloss nitrocellulose-acrylic lacquers (MIL-L-19537) which exhibited fine blistering in the humidity test (Table 6), all were satisfactory. When these same lacquers were applied over MIL-P-23377 epoxy primer (Systems 1(a), 2(a), 3(a)), there was no evidence of failure in these tests. Additionally, after the 1-year exposure at both the APG and Panama test sites, there was no film failure or corrosion with any of the systems.

7. **Knife Test.** In the knife test (Tables 11 and 12), adhesion of all systems to the metal was considered very satisfactory; however, some of the nitrocellulose acrylic lacquers exhibited poor adhesion to the primer and excessively brittle films (flaked off when cut). The experimental urethane-acrylic enamel was tough but very brittle, and the MIL-C-83286 white urethane had an excessively heavy dirt pickup which could not be washed away. The remaining urethane coatings and the acrylic lacquer provided hard, tough films with varying degrees of system flexibility and are considered to provide general, adequate film properties.

8. **Weathering Characteristics.**

a. **Gloss Coatings.** The gloss urethanes generally exhibited higher initial gloss and better gloss retention than the specification acrylic and nitrocellulose-acrylic lacquers after weathering for 1 year. However, after 2 year's exposure in Panama (Table 9), the gloss of all the coatings is comparable. Rates of chalking are also comparable.

b. **Lusterless Coatings.** After the first year's exposure, no significant differences were noted in the weathering properties of the lusterless finishes. After 2 years, however, the ratings (Table 4) indicated a generally faster rate of chalking for the urethane coatings. In the knife test (Table 12), with few exceptions (Systems 15(a), 16(a), 28, 28(b)), all systems exhibited satisfactory intercoat and metal adhesion. The major differences were in the better flexibility of the urethane systems.

c. **Urethane Coatings.** The improved initial gloss and gloss retention during exterior exposure provided by the urethane coatings make them desirable for use on Army aircraft requiring a gloss finish. Of the two specification materials, MIL-C-83286 showed the better properties; however, since initiation of this program, the requirements for MIL-C-81773 have been revised to upgrade its performance by changes in accelerated weathering, flexibility, and lube oil resistance requirements.[11] It is also anticipated that efforts will be made in the near future to integrate both specifications.

Of the nonspecification urethane coatings, the one-package, moisture-cure coatings closely approached the required performance; and consideration should be given for further development to bring this type coating up to the required performance level. It may also provide a handling advantage as a "touch-up" coating in the field by eliminating the need for mixing small quantities of two-component materials with limited pot life. The experimental urethane-acrylic exhibited significantly better gloss and gloss retention after the 1-year tropical exposure than any of the other materials and would warrant additional studies toward development of a urethane-acrylic providing other properties required by MIL-C-83286.

9. **Test Results.** The test results are summarized in Table 13 and show the urethanes to generally provide better impact flexibility, fluid resistance, and abrasion resistance than the specification lacquers MIL-L-19537, MIL-L-19538, and MIL-L-81352. The gloss urethanes also showed higher initial gloss and gloss retention during weathering (Table 13 and Figures 1 and 2). To date, there are no significant differences in the weathering properties of the lusterless finishes.

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[11] Naval Air Development Center Report No. NADC 73038-30, "Evaluation of Proprietary Aliphatic Polyurethane Topcoats Phase Report," Feb 9, 1973.

IV. CONCLUSIONS

10. Conclusions. Based upon the data obtained in this study and taking into consideration such things as application ease, cost, and operational requirements, the following painting systems should be used on Army aircraft:

a. **Gloss.** Where a full-gloss finish is required, Military Specification MIL-C-83286 gloss urethane coating should be used. Even though the gloss of the urethane coating dropped to the level of the MIL-L-19537 and MIL-L-81352 aircraft lacquers after 2-year weathering in Panama, its initial appearance and gloss make it preferable for use on V.I.P. aircraft. Routine cleaning procedures should maintain the Initial appearance for an extended period of time.

b. **Lusterless.** Where a lusterless finish is required, Military Specification MIL-L-81352 acrylic lacquer should be used. This lacquer is considered to have the best balance of properties to provide optimum cost effectiveness. Although it does not possess the system flexibility of the urethanes, its adhesion is comparable and resistance to chalking is better. The added flexibility is not considered critical because Army aircraft will not encounter the sudden temperature changes and metal stresses that occur with high-speed aircraft of the other services.

Table 1. Coatings Evaluated

Coating Number	Code or Batch Number	Supplier	Specification	Binder Type	Color	Gloss
1	740-1661	CCL	MIL-L-19537	Nitrocellulose-Acrylic	Olive Drab	Full Gloss
2	1K6642	Lenmar Lacquers*	"	"	"	"
3	740-1651	CCL	"	"	White	"
4	IN7629	Lenmar Lacquers*	"	"	"	"
5	IK6399	Lenmar Lacquers*	MIL-L-81352	"	Olive Drab	"
6	740-1681	CCL	"	"	White	"
7	–	Andrew Brown	MIL-C-81773	2-Pkg Urethane	Olive Drab	"
8	–	Andrew Brown	"	"	White	"
9	4-W-89	Midland-Dexter	MIL-C-83286	"	"	"
10	–	DeSoto	"	"	"	"
11	A276	Hughson Chemical Co.	None	1-Pkg Urethane	"	"
12	TS-2310-18	Hughson Chemical Co.	"	"	Olive Drab	"
13	750-751	CCL	"	2-Pkg Urethane-Acrylic	White	"
14	740-1631	CCL	MIL-L-19538	Nitrocellulose-Acrylic	Olive Drab	Lusterless
15	740-1641	CCL	"	"	White	"
16	1K6399	Lenmar Lacquers*	"	"	"	"
17	746-1721	CCL	MIL-L-81352	Acrylic	Olive Drab	"
18	2C8436	Lenmar Lacquers*	"	"	"	"
19	740-1731	CCL	"	"	"	"
20	740-1682	CCL	"	"	White	"
21	70-799	Enmar*	"	"	"	"
22	–	Andrew Brown	MIL-C-81773	2-Pkg Urethane	Olive Drab	"
23	–	Andrew Brown	"	"	White	"
24	–	DeSoto	MIL-C-83286	"	Dark Green	"
25	–	DeSoto	"	"	White	"
26	4G114	Midland-Dexter	"	"	Dark Green	"
27	TS2310-17	Hughson Chemical Co.	None	1-Pkg Urethane	Olive Drab	"
28	TS1951-50	Hughson Chemical Co.	"	"	White	"

* Procured from General Services Administration stocks.

Table 2. Specification Requirement Summary

	MIL-C-83286	MIL-C-81773	MIL-L-81352
Drying time (hr, max)			
Dry to recoat	1	–	–
Set to touch	2	–	–
Dry hard	6	8	2/3
Specular gloss			
60°–Gloss	85	90 min.	White: 65; OD: 70 min.
–Camouflage	7-12	5 max.	10 max.
20°–Gloss	–	75 min.	–
Adhesion			
Tape (24 hr in H_2O, dry, tape)	No adhesion loss between coats, topcoat & primer, primer & metal		
Knife test	–	Ribbons without flaking or paration from itself, primer, metal	
Flexibility			
Impact–7-day cure	No cracking, crazing, removal by tape	–	–
7-day cure + 4 hr 300°F	" " " " " "	–	–
7-day cure + 500 hr W/O	" " " " " "	–	–
7-day cure + 24 hr diester @ 250°F	" " " " " "	–	–
7-day cure + 1-yr weathering	" " " " " "	–	–
Bend-Gloss	–	No cracking, peeling, loss of adhesion: 1/8" bend	–
Camouflage	–	1/4" bend	–
Cold cracking (cold water)	–	–	–
Low temperature (-50° C, 4 hr)	No cracking, crazing, removal gloss: 3/8"; camouflage: 1/2" rod	–	–
Immersion			
Lubricating oil (sebacate–TCP)[a]	–	4 hr–250°F. No blistering; film softening	24 hr–350°F. No blistering, softening or other film defects
Lubricating oil (adipate–TCP)[b]	24 hr–250°F	No leaching, adhesion	–	–
MIL-H-5606 (hydraulic fluid)	7 days std cond	loss, corrosion–	–	–
Skydrol 500B (hydraulic fluid)	7 days std cond	1-pencil hardness.	–	–
Hydrocarbon fluid (Type III, TT-S-735)	7 days std cond		–	4 hr R.T. no blisters, film failure
Water	4 days–100°F	Decrease max. Skydrol– 2-pencil hardness max.	–	24 hr R.T. no cracks, blisters, film failures
Humidity	30 days–95% RH–120°F No adhesion loss, blisters, or softening		18 days–95% RH–200°F No softening, or loss of adhesion	–
Salt Spray, 5%–500 hr	No corrosion		–	–
Accelerated weathering	500 hr–Same gloss, color, impact as unexposed coating		168 hr–No chalking, excessive color change; gloss not less than 65 for gloss finish	–
Weather resistance (1 yr, Florida)	Meets color, impact, & gloss requirements of spec		No cracking, crazing, or chalking; 60° gloss–55 min.	No greater deterioration than control; good intercoat adhesion

(a) 95% di-2 ethyl hexyl sebacate, 5% tricresyl phosphate.

(b) 98% diisoctyl adipate, 2% tricresyl phosphate.

Table 2. Specification Requirement Summary (Continued)

	MIL-L-19537	MIL-L-19538
Drying time (hr, max)		
Dry to recoat	–	–
Set to touch	–	–
Dry hard	2/3	2/3
Specular gloss		
60° – Gloss	White: 67; OD – 75 min.	–
– Camouflage	–	5 max.
20° – Gloss	–	–
Adhesion		
Tape (24 hr in H_2O, dry, tape)	No adhesion loss between coats, topcoat and primer, primer and metal	
Knife test	Ribbons without flaking or paration from itself, primer, metal	
Flexibility		
Impact – 7-day cure	–	–
7-day cure + 4 hr 300°F	–	–
7-day cure + 500 hr W/O	–	–
7-day cure + 24 hr diester @ 250°F	–	–
7-day cure + 1-yr weathering	–	–
Bend – Gloss	–	–
Camouflage	–	–
Cold cracking (cold water)	No flaking – 1/4" – fine cracks OK	No flaking – 1/4" – fine cracks OK
Low temperature (-50°C, 4 hr)	–	–
Immersion		
Lubricating oil (sebacate – TCP)[a]	2 hr – 250°F – No blisters, softening, or other failure	
Lubricating oil (adipate – TCP)[b]	–	–
MIL-H-5606 (hydraulic fluid)	–	–
Skydrol 500B (hydraulic fluid)	–	–
Hydrocarbon fluid (Type III, TT-S-735)	4 hr R.T. – no blisters, film failures	4 hr R.T. – no blistering, film failures
Water	24 hr R.T. – no cracks, blisters, film failures	24 hr R.T. – no cracks, blisters, film failures
Humidity	–	–
Salt Spray, 5% – 500 hr	–	–
Accelerated weathering	–	–
Weather resistance (1 yr, Florida)	No greater deterioration than control; good intercoat adhesion	

(a) 95% di-2 ethyl hexyl sebacate, 5% tricresyl phosphate.
(b) 98% diisoctyl adipate, 2% tricresyl phosphate.

Table 3. Coating Systems

Specification	System	Dry-Film Thickness (mils)
MIL-L-19537	Wash Primer, MIL-C-8514	0.2 – 0.3
	Lacquer Primer, MIL-P-7962	0.3 – 0.4
	Topcoat, MIL-L-19537	0.8 – 1.2
MIL-L-19538	Wash Primer, MIL-C-8514	0.2 – 0.3
	Lacquer Primer, MIL-P-7962	0.3 – 0.4
	Topcoat, MIL-L-19538	0.8 – 1.2
MIL-C-81352	Epoxy Primer, MIL-P-23377	0.6 – 0.9
	Topcoat, MIL-C-81352	1.0 – 1.4
MIL-C-81773	Epoxy Primer, MIL-P-23377	0.6 – 0.9
	Topcoat, MIL-C-81773	1.0 – 1.5
MIL-C-83286	Epoxy Primer, MIL-P-23377	0.6 – 0.9
	Topcoat, MIL-C-83286	1.7 – 2.3
None	Epoxy Primer, MIL-P-23377	0.6 – 0.9
	Topcoat – Proprietary 1-Pkg Urethane	1.0 – 1.5
None	Epoxy Primer, MIL-P-23377	0.6 – 0.9
	Topcoat – Experimental Acrylic Urethane	1.0 – 1.5

Table 4. Physical Properties – Gloss Coatings

Coating Number	MIL Specification	Wet-Tape Adhesion	Resistance to Taping	Impact Flexibility (%) A	B	C	D	C-83286 Requirement
1	L-19537	OK	OK	!	½	½	5	60°
1[a]	↓	↓	↓	↓	↓	1	↓	↓
2	↓	↓	↓	↓	↓	½	10	↓
2[a]	↓	↓	↓	↓	↓	2	5	↓
3	↓	↓	↓	2	↓	½	1	↓
3[a]	↓	↓	↓	5	↓	↓	1	↓
4	↓	↓	↓	1	↓	↓	½	↓
4[a]	↓	↓	↓	2	↓	↓	2	↓
5	L-81352	↓	↓	½	↓	10	2	↓
6	↓	↓	↓	↓	↓	½	½	↓
7	C-81773	↓	↓	60	60	↓	60	↓
8	↓	↓	↓	↓	↓	↓	2	↓
9	C-83286	↓	↓	20	20	↓	20	↓
10	↓	↓	↓	60	60	↓	60	↓
11	None	↓	Marred	↓	↓	↓	40	↓
12	↓	↓	↓	↓	↓	↓	60	↓
13	↓	↓	↓	5	10	20	5	↓

(a) – MIL-P-23377 primer instead of standard MIL-C-8514/MIL-P-7962 primer system required by MIL-L-19537.

NOTE: A – 7-day cure. C – 7-day cure plus 24-hour immersion in diester fluid at 250°F.
B – 7-day cure plus 300°F – 4 hours. D – After 500 hours accelerated weathering.

Table 5. Physical Properties – Lusterless Coatings

Coating Number	MIL Specification	Wet-Tape Adhesion	Resistance to Taping	Impact Flexibility (%) A	B	C	D	C-83286 Requirement
14	L-19538	OK	OK	2	20	2	5	20°
14[a]	↓	↓	↓	10	40	10	40	↓
15	↓	↓	↓	1	½	½	1	↓
15[a]	↓	↓	↓	2	↓	↓	2	↓
16	↓	↓	↓	1	10	↓	1	↓
16[a]	↓	↓	↓	5	↓	5	5	↓
17	L-81352	↓	↓	1	2	↓	1	↓
18	↓	↓	↓	5	5	10	↓	↓
19	↓	↓	↓	↓	10	↓	↓	↓
20	↓	↓	↓	2	↓	2	2	↓
21	↓	↓	↓	↓	5	↓	↓	↓
22	C-81773	↓	↓	5	↓	5	5	↓
23	↓	↓	↓	↓	↓	↓	↓	↓
24	C-83286	↓	↓	20	40	20	20	↓
25	↓	↓	↓	10	10	10	10	↓
26	↓	↓	↓	20	40	20	20	↓
27	None	↓	↓	↓	20	↓	↓	↓
28	↓	↓	↓	↓	↓	↓	↓	↓

(a) – MIL-P-23377 primer instead of standard MIL-C-8514/MIL-P-7962 primer system required by MIL-L-19538.

NOTE: A – 7-day cure.
B – 7-day cure plus 300°F – 4 hours.
C – 7-day cure plus 24-hour immersion in diester fluid at 250°F.
D – After 500 hours accelerated weathering.

Table 6. Resistance Properties – Gloss Coatings

Coating Number	MIL Specification	Salt Spray	Humidity	Heat[b]	Flexibility (5 [illegible])	
					-50°C	After [illegible] ometer
1	L-19537	Fine Blisters	Fine Blisters	Fails	Cracked	Cra[illegible]
1[a]	↓	OK	OK	↓	↓	↓
2	↓	↓	↓	↓	↓	OK
2[a]	↓	↓	↓	↓	↓	Cracked
3	↓	Fine Blisters	Fine Blisters	↓	↓	↓
3[a]	↓	OK	OK	↓	↓	↓
4	↓	Fine Blisters	↓	↓	↓	↓
4[a]	↓	OK	↓	↓	↓	↓
5	L-81352	↓	↓	↓	↓	OK
6	↓	↓	↓	↓	↓	Cracked
7	C-81773	↓	↓	OK	↓	OK
8	↓	↓	↓	↓	↓	Cracked
9	C-83286	↓	↓	Fails	↓	OK
10	↓	↓	↓	OK	OK	↓
11	None	↓	↓	↓	Cracked	↓
12	↓	↓	↓	↓	↓	↓
13	↓	↓	↓	Fails	↓	Cracked

(a) – MIL-P-23377 primer instead of standard MIL-C-8514/MIL-P-7962 primer system required by MIL-L-19537.
(b) – See Table 4 – Impact Flexibility, Column B.

Table 6. Resistance Properties – Gloss Coatings (*Continued*)

Coating Number	MIL Specification	Pencil Hardness – Fluid Resistance[b]											Abrasion[d] (Wear Index)
		Before Exposure	Lube Oil[c]		Hydrocarbon[c] Fluid		Hydraulic[c] Fluid		Skydrol[c] 500B		Water[c]		
1	L-19537	HB	6B	(6)	4B	(4)	B	(1)	Dissolved		4B[e]	(4)	–
1[a]	↓	↓	↓	↓	↓	↓	HB	(0)	↓	↓	↓	(4)	–
2	↓	F	↓	(7)	↓	(5)	↓	(1)	↓	↓	F	(0)	113
2[a]	↓	↓	↓	↓	F	(0)	F	(0)	↓	↓	4B[e]	(5)	–
3	↓	↓	↓	↓	4B	(5)	HB	(1)	↓	↓	↓	↓	–
3[a]	↓	↓	↓	↓	3B	(4)	↓	↓	↓	↓	↓	↓	–
4	↓	↓	↓	↓	HB	(1)	↓	↓	↓	↓	↓	↓	138
4[a]	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	–
5	L-81352	3H	4B	(8)	↓	(4)	3H	(0)	↓	↓	3H	(0)	115
6	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	113
7	C-81773	HB	HB	(0)	↓	(0)	HB	↓	3B	(3)	HB	↓	46
8	↓	↓	↓	↓	↓	↓	↓	↓	5B	(5)	↓	↓	52
9	C-83286	H	H	↓	F	(1)	H	↓	F	(1)	H	↓	23
10	↓	HB	HB	↓	HB	(0)	HB	↓	HB	(0)	HB	↓	26
11	None	↓	↓	↓	↓	↓	↓	↓	(f)	↓	↓	↓	53
12	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	39
13	↓	H	H	↓	H	↓	H	↓	H	↓	H	↓	73

(a) – MIL-P-23377 primer instead of standard MIL-C-8514/MIL-P-7962 primer system required by MIL-L-19537.
(b) – MIL-C-83286 requirement – no more than 2 units change in Skydrol nor more than 1 unit, all other fluids.
(c) – Units change given in parenthesis.
(d) – Taber abrasion according to Federal Test Method Standard No. 141, Method 6192, with CS17 wheels, 1000-gm load. Not a MIL-C-83286 requirement.
(e) – Blistered.
(f) – 40% loss of gloss.

Table 6. Resistance Properties – Gloss Coatings (Continued)

Coating Number	MIL Specification	Accelerated Weathering[b]				
		60° Gloss		Units Loss	Percent Retention	Visual Appearance
		Initial	Final			
1	L-19537	82	47	35	51	OK
1[a]	↓	65	40	25	62	↓
2	↓	77	34	43	44	↓
2[a]	↓	65	34	31	52	↓
3	↓	65	42	23	65	↓
3[a]	↓	67	47	20	70	↓
4	↓	72	42	30	58	↓
4[a]	↓	60	45	15	75	↓
5	L-81352	75	35	40	47	↓
6	↓	62	48	14	77	↓
7	C-81773	92	47	45	51	Faded
8	↓	95	67	28	71	OK
9	C-83286	93	87	6	94	↓
10	↓	88	77	11	88	↓
11	None	93	77	16	83	↓
12	↓	80	55	25	69	↓
13	↓	97	78	19	80	↓

(a) – MIL-P-23377 primer instead of standard MIL-C-8514/MIL-P-7962 primer system required by MIL-L-19537.
(b) – For Impact Flexibility, see Table 4.

Table 7. Resistance Properties – Lusterless Coatings

Coating Number	MIL Specification	Salt Spray	Humidity	Heat[b]	Flexibility (½-in. Bend)	
					-50°C	After Weatherometer
14	L-19538	OK	OK	OK	Cracked	Cracked
14[a]						OK
15				Fails		Cracked
15[a]						OK
16						Cracked
16[a]						OK
17	L-81352					Cracked
18						
19						
20						OK
21					OK	Cracked
22	C-81773				Cracked	OK
23						
24	C-83286			OK		
25				Fails		
26				OK		
27	None					
28						

(a) – MIL-P-23377 primer instead of standard MIL-C-8514/MIL-P-7962 primer system required by MIL-L-19538.
(b) – See Table 5 – Impact Flexibility, Column B.

Table 7. Resistance Properties – Lusterless Coatings (Continued)

Coating Number	MIL Specification	Pencil Hardness – Fluid Resistance[b]											Abrasion[d] (Wear Index)
		Before Exposure	Lube Oil[c]		Hydrocarbon[c] Fluid		Hydraulic[c] Fluid		Skydrol[c] 500B		Water[c]		
14	L-19538	F	6B	(7)	4B	(5)	HB	(1)	Dissolved		5B	(6)	–
14[a]	↓	↓	2B	(3)	HB	(1)	↓	↓	↓		4B	(5)	–
15	↓	↓	6B	(7)	4B	(5)	↓	↓	↓		5B[e]	(6)	171
15[a]	↓	↓	↓	↓	HB	(1)	↓	↓	↓		3B	(4)	–
16	↓	↓	↓	↓	3B	(4)	↓	↓	↓		6B	(7)	–
16[a]	↓	↓	↓	↓	HB	(1)	↓	↓	↓		4B	(5)	–
17	L-81352	3H	3B	↓	↓	(4)	3H	(0)	↓		3H	(0)	135
18	↓	↓	↓	↓	↓	↓	↓	↓	↓		↓	↓	–
19	↓	5H	H	(4)	2H	(3)	5H	↓	↓		5H	↓	–
20	↓	3H	4B	(8)	HB	(4)	3H	↓	↓		3H	↓	133
21	↓	4H	↓	(9)	H	(3)	4H	↓	↓		4H	↓	–
22	C-81773	7H	HB	(8)	7H	(0)	7H	↓	4B	(12)	7H	↓	55
23	↓	5H	↓	(6)	5H	↓	5H	↓	B	(7)	5H	↓	50
24	C-83286	8H	8H	(0)	8H	↓	8H	↓	8H	(0)	8H	↓	36
25	↓	5H	5H	(0)	5H	↓	5H	↓	3H	(2)	5H	↓	35
26	↓	7H	7H	(0)	7H	↓	7H	↓	6H	(1)	7H	↓	37
27	None	HB	HB	(0)	4B	(4)	HB	↓	Dissolved		HB	↓	96
28	↓	↓	↓	↓	↓	↓	↓	↓	↓		↓	↓	92

(a) – MIL-P-23377 primer instead of standard MIL-C-8514/MIL-P-7962 primer system required by MIL-L-19538.
(b) – MIL-C-83286 requirement – no more than 2 units change in Skydrol; no more than 1 unit all other fluids.
(c) – Units change given in parenthesis.
(d) – Taber abrasion according to Federal Test Method Standard No. 141, Method 6192, with CS17 wheels, 100-gm load. Not a MIL-C-83286 requirement.
(e) – Blistered.

Table 7. Resistance Properties – Lusterless Coatings (Continued)

Coating Number	MIL Specification	Accelerated Weathering[b]			
		60° Gloss		Units Loss	Visual Appearance
		Initial	Final		
14	L-19538	1	0	1	OK
14[a]	↓	1	0	1	↓
15	↓	9	5	4	↓
15[a]	↓	7	5	2	↓
16	↓	3	2	1	↓
16[a]	↓	3	2	1	↓
17	L-81352	11	7	4	↓
18	↓	4	2	2	↓
19	↓	0	0	0	↓
20	↓	12	12	0	↓
21	↓	5	4	1	↓
22	C-81773	0	0	0	↓
23	↓	1	1	↓	↓
24	C-83286	0	0	↓	↓
25	↓	1	1	↓	↓
26	↓	5	4	1	↓
27	None	1	0	↓	↓
28	↓	12	11	↓	↓

(a) – MIL-P-23377 primer instead of standard MIL-C-8514/MIL-P-7962 primer system required by MIL-L-19538.
(b) – For Impact Flexibility, see Table 5.

Table 8. Exterior Exposure – Gloss Coatings (APG)

Coating Number	MIL Specification	6 Months							12 Months				
		60° Gloss			20° Gloss				60° Gloss		20° Gloss		
		Before	After	Units Change	Before	After	Units Change	Chalking ASTM	After	Units Change	After	Units Change	Chalking ASTM
1	L-19537	76	71	-5	32	27	-5	7	68	-8	19	-13	7
1(a)		75	63	-12	28	25	-3		58	-17	13	-15	6
2		75	71	-4	35	31	-4		64	-11	18	-17	8
2(a)		76	65	-11	35	18	-17		58	-18	11	-24	7
3		58	56	-2	13	12	-1		39	-19	4	-9	6
3(a)		56	49	-7	13	6	-7	8	30	-26	1	-12	6
4		76	74	-2	39	29	-10	6	55	-21	15	-24	6
4(a)		66	68	+2	21	20	-1	7	53	-13	12	-9	7
5	L-81352	77	75	-2	46	51	+5	6	64	-13	21	-25	7
6		61	67	+6	18	21	+3	7	65	+4	19	+1	7
7	C-81773	81	68	-13	44	22	-22		61	-20	12	-32	6
8		91	88	-3	75	72	-3	8	88	-3	50	-25	6
9	C-83286	93	93	0	83	79	-4	7	92	-1	55	-28	8
10		88	82	-6	76	69	-7	6	77	-11	47	-29	6
11	None	91	80	-11	73	52	-21	7	53	-38	23	-50	6
11(b)		92	83	-9	78	63	-15		71	-21	36	-42	6
12		78	74	-4	39	36	-3	6	52	-26	11	-28	6
12(b)		63	63	0	14	17	+3		67	+4	23	+9	6
13		95	91	-4	85	91	+6	7	86	-9	62	-23	8

(a) – MIL-P-23377 primer instead of standard MIL-C-8514/MIL-P-7962 primer system required by MIL-L-19537.
(b) – Company-supplied primer instead of MIL-P-23377 primer.

Table 9. Panama Exposure (Gloss Coatings)

Coating Number	MIL Specification	Gloss Months Exposure 60° 0	6	12	24	20° 0	6	12	24	Chalking Months Exposure 6	12	24
1	L-19537	76	56	52	31	34	12	13	1	6	6	8
1[a]		76	38	36	29	31	4	4	0	6	6	7
2		79	62	41	21	42	17	4	1	6	6	7
2[a]		75	38	30	21	32	3	1	1	6	6	7
3		61	36	32	10	12	3	2	1	7	6	6
3[a]		55	11	14	10	12	7	0	1	7	6	6
4		72	63	39	25	41	17	3	1	7	6	6
4[a]		78	35	32	26	41	1	2	1	7	6	6
5	L-81352	75	69	63	35	36	27	19	5	8	7	8
6		61	66	68	15	19	22	24	1	7	6	8
7	C-81773	83	–	9	4	41	–	1	0	–	6	6
8		90	78	50	21	80	37	11	1	6	8	6
9	C-83286	86	87	81	18	86	73	48	1	7	8	8
10		90	66	65	26	75	37	14	1	6	7	8
11	None	92	78	54	6	72	41	17	1	7	8	7
11[b]		92	70	30	5	75	34	8	1	7	8	6
12		80	71	55	19	38	28	14	0	7	8	7
12[b]		63	57	38	12	14	12	4	1	8	8	7
13		95	87	84	31	85	70	54	8	7	8	7

(a) – MIL-P-23377 primer instead of standard MIL-C-8514/MIL-P-7962 primer system required by MIL-L-19537.
(b) – Company-supplied primer instead of MIL-P-23377 primer.

Table 10. Panama Exposure (Lusterless Coatings)

Coating Number	MIL Specification	60° Gloss Months Exposure				Chalking Months Exposure		
		0	6	12	24	6	12	24
14	L-19538	1	1	0	1	8	8	7
14[a]		1	1	0	1	8	8	7
15		12	7	9	5	8	7	6
15[a]		16	5	5	4	8	8	6
16		4	3	3	3	7	8	7
16[a]		4	2	2	3	7	6	6
17	L-81352	9	11	10	10	6	7	8
18		3	6	6	4	7	8	6
19		0	1	0	1	8	8	8
20		6	9	9	5	6	7	8
21		4	4	2	3	7	7	6
22	C-81773	0	0	0	1	8	6	6
23		1	1	1	2	6	4	4
24	C-83286	0	0	0	0	8	6	5
25		1	1	1	2	7	7	4
26		5	5	5	4	7	8	8
27	None	1	1	1	0	8	6	5
27[b]		1	1	0	1	8	6	5
28		37	31	19	5	8	8	5
28[b]		20	17	7	4	7	8	6

(a) – MIL-P-23377 primer instead of standard MIL-C-8514/MIL-P-7962 primer system required by MIL-L-19538.
(b) – Proprietary primer instead of MIL-P-23377 primer.

Table 11. Knife Test (Gloss Coatings)

Coating Number	MIL Specification	Adhesion[c] Topcoat Primer	Adhesion[c] System-Metal	System Flexibility[d]	Film Properties
1	L-19537	Poor	Good	Very Good	Tough
1[a]		Fair		Fair	Hard, Tough
2		Good		Poor	Brittle, Flakes
2[a]		Good		Fair	Brittle, Flakes
3		Poor		Very Good	Topcoat Brittle, Primer System OK
3[a]		Good		Fair	Hard-Brittle, Flakes
4		Fair		Very Good	Topcoat Brittle, Flakes; Primer System OK
4[a]		Poor		Very Good	Topcoat Brittle, Flakes; Primer System OK
5	L-81352	Good		Fair	Hard, Tough
6				Fair	Hard, Tough
7	C-81773			Very Good	Tough
8				Fair	Very Hard, Tough
9	C-83286			Good	Hard, Tough
10				Very Good	Tough, Heavy Dirt Pickup
11	None			Very Good	Hard, Tough
11[b]				Good	Hard, Tough
12				Excellent	Hard, Tough
12[b]				Excellent	Hard, Tough
13				Fair	Tough, Brittle, Flakes

(a) – MIL-P-23377 primer instead of standard MIL-C-8514/MIL-P-7962 primer system required by MIL-L-19537.

(b) – Proprietary primer instead of MIL-P-23377 primer.

(c) Poor – Topcoat easily separates from primer or primer, from metal.
Fair – With effort, topcoat can be separated from primer or primer, from metal.
Good – Topcoat cannot be separated from primer. Very difficult to remove primer from metal.

(d) Poor – Flakes.
Fair – Powders.
Good – Starts to ribbon, then crumbles.
Very Good – Forms Ribbon, easily broken.
Excellent – Forms continuous ribbon.

Table 12. Knife Test (Lusterless Coatings)

Coating Number	MIL Specification	Adhesion[c] Topcoat Primer	Adhesion[c] System-Metal	System Flexibility[d]	Film Properties
14	L-19538	Good	Good	Good	Hard, Tough
14[a]	↓	↓	↓	Very Good	↓
15	↓	↓	↓	Good	↓
15[a]	↓	↓	↓	Poor	Brittle, Flakes
16	↓	↓	↓	Good	Hard, Tough
16[a]	↓	↓	↓	Fair	↓
17	L-81352	↓	↓	Good	↓
18	↓	↓	↓	↓	Hard, Very Tough
19	↓	↓	↓	↓	Hard, Tough
20	↓	↓	↓	↓	↓
21	↓	↓	↓	↓	Hard, Very Tough
22	C-81773	↓	↓	Very Good	Hard, Tough
23	↓	↓	↓	Good	↓
24	C-83286	↓	↓	Excellent	↓
25	↓	↓	↓	Very Good	↓
26	↓	↓	↓	Excellent	↓
27	Hughson	↓	↓	↓	↓
27[b]	↓	↓	↓	↓	↓
28	↓	↓	↓	Poor	Brittle, Flakes
28[b]	↓	Fair	↓	Good	Topcoat Brittle; Primer Good

(a) – MIL-P-23377 primer instead of standard MIL-C-8514/MIL-P-7962 primer system required by MIL-L-19538.

(b) – Proprietary primer instead of MIL-P-23377 primer.

(c) Poor – Topcoat easily separates from primer or primer, from metal.
Fair – With effort, topcoat can be separated from primer or primer, from metal.
Good – Topcoat cannot be separated from primer. Very difficult to remove primer from metal.

(d) Poor – Flakes.
Fair – Powders.
Good – Starts to ribbon, then crumbles.
Very Good – Forms ribbon, easily broken.
Excellent – Forms continuous ribbon.

Table 13. Test Data Summary

Test	Gloss																
	MIL-L-19537								MIL-L-81352		MIL-C-81773		MIL-C-83286		One-Pkg Urethane		Experimental Urethane Acrylic
Coating Number	1	1a	2	2a	3	3a	4	4a	5	6	7	8	9	10	11	12	13
Wet-tape adhesion	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Impact flexibility																	
A – 7-day cure											X	X		X	X	X	
B – 7-day cure – 300°F – 4 hr											X	X		X	X	X	
C – 24 hr diester – 250°F														X			
D – After accelerated weathering											X			X			
Salt Spray–500 hr–5%		X	X	X		X		X	X	X	X	X	X	X	X	X	X
Humidity–120°F–30 days		X	X	X		X	X	X	X	X	X	X	X	X	X	X	X
Low-temperature flexibility (-65°F)														X			
Fluid resistance																	
Diester lube oil											X	X	X	X	X	X	X
Hydrocarbon TT-S-735				X			X	X			X	X	X	X	X	X	X
Hydraulic MIL-H-5606	X	X	X	X	X	X	X	X	X	X	XX	X	X	X	X	X	X
Skydrol 500B													X	X	X	X	X
Distilled water			X						X	X	X	X	X	X	X	X	X
Resistance to taping	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
Flexibility after accelerated weathering			X						X		X		X	X	X	X	
Wear Index	–	–	113	–	–	–	138	–	115	113	46	52	23	26	53	39	73
Accelerated weathering																	
Initial 60° gloss	82	65	77	65	65	67	72	60	75	62	92	95	93	88	93	80	97
Final	47	40	34	34	42	47	42	45	35	48	47	67	87	77	77	55	78
Exterior exposure–12 months																	
APG–Initial 60° gloss	76	75	75	76	58	56	76	66	77	61	81	91	93	88	92	78	95
Final	68	58	64	58	39	30	55	53	64	65	61	88	92	77	71	52	86
Initial 20° gloss	32	28	35	35	13	13	39	21	46	18	44	75	83	76	78	39	85
Final	19	13	18	11	4	1	15	12	21	19	12	50	55	47	36	11	62
Chalking	7	6	8	7	6	6	6	7	7	7	6	6	8	6	6	6	8
Panama–Initial 60° gloss	76	76	79	~~75~~	61	55	72	78	75	61	83	90	86	90	92	80	95
Final	52	40	41	30	32	14	39	32	63	68	9	50	81	65	54	55	84
Initial 20° gloss	34	31	42	32	12	12	41	41	36	19	41	80	86	75	75	38	85
Final	13	4	4	1	2	0	3	2	19	24	0	11	48	14	17	14	54
Chalking	6	6	6	6	6	6	6	6	7	6	6	8	8	7	8	8	8

X – Meets MIL-C-83286 requirements.
– Not tested.

Table 13. Test Data Summary (Continued)

Test	Lusterless																	
	MIL-L-19538						MIL-L-81352					MIL-C-81773		MIL-C-83286			One-Pkg Urethane	
Coating Number	14	14a	15	15a	16	16a	17	18	19	20	21	22	23	24	25	26	27	28
Wet-Tape Adhesion	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Impact flexibility																		
A – 7-day cure														X		X	X	X
B – 7-day cure–300°F–4 hr	X	X												X		X	X	X
C – 24 hr diester–250°F														X		X	X	X
D – After accelerated weathering		X												X		X	X	X
Salt spray–500 hr–5%	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Humidity–120°F–30 days	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Low-temperature flexibility (-65°F)											X							
Fluid resistance																		
Diester lube oil														X	X	X	X	X
Hydrocarbon TT-S-735		X		X		X						X	X	X	X	X		
Hydraulic MIL-H-5606	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Skydrol 500B														X	X	X		
Distilled water							X	X	X	X	X	X	X	X	X	X	X	X
Resistance to taping	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Flexibility after accelerated weathering		X		X		X				X		X	X	X	X	X	X	X
Wear index	–	–	171	–	–	–	135	–	–	133	–	55	50	36	35	37	96	92
Accelerated weathering																		
Initial 60° gloss	1	1	9	7	3	3	11	4	0	12	5	0	1	0	1	5	1	12
Final	0	0	5	5	2	2	7	2	0	12	4	0	1	0	1	4	0	11
Exterior exposure–12 months																		
APG–Initial 60° gloss	1	1	12	16	4	4	9	3	0	6	4	0	1	0	1	5	1	20
Final	1	2	12	12	4	4	10	7	0	9	4	0	1	0	1	5	2	23
Initial 20° gloss	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Final	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chalking	8	8	8	6	8	6	7	8	8	8	7	7	6	8	7	8	8	6
Panama–Initial 60° gloss	1	2	12	16	4	4	8	3	0	5	4	0	1	0	1	5	1	20
Final	0	0	9	5	3	2	17	6	0	9	2	0	1	0	1	5	0	7
Initial 20° gloss	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Final	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chalking	8	8	7	8	8	6	8	8	8	7	7	6	4	6	7	8	6	8

X – Meets MIL-C-83286 requirements.
– Not tested.

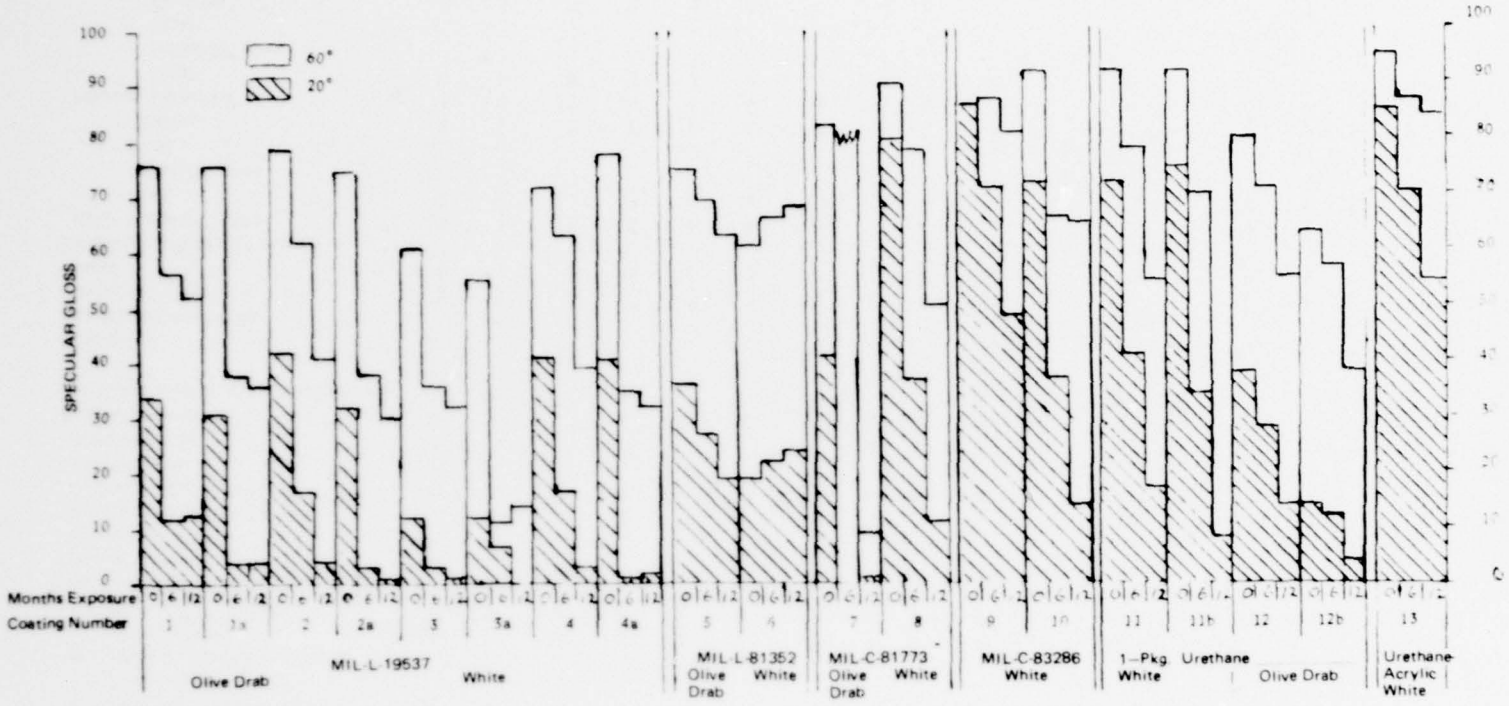

Figure 1. Gloss retention – Panama exposure.

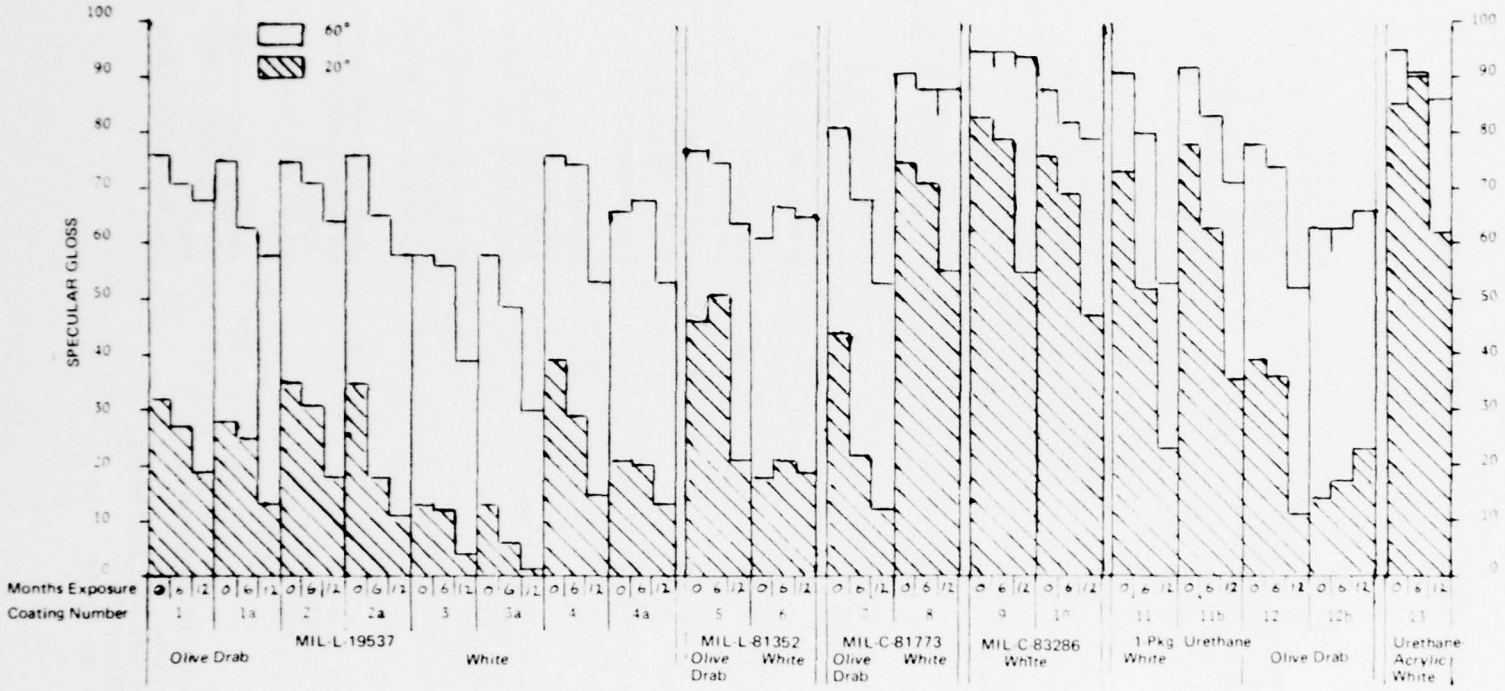

Figure 2. Gloss retention – APG exposure.

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